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UTILITY
PATENT APPLICATION
TRANSMITTAL

(For new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.

200246US2

First Inventor or Application Identifier

Masaki NARUSHIMA

Title

CERAMIC HEATER SYSTEM AND SUBSTRATE PROCESSING
APPARATUS HAVING THE SAME INSTALLED THEREIN

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents

ADDRESS TO: Assistant Commissioner for Patent
Box Patent Application
Washington, DC 20231

- 1.
- ☒
- Fee Transmittal Form (e.g. PTO/SB/17)
-
- (Submit an original and a duplicate for fee processing)

- 2.
- ☒
- Specification Total Sheets
- 38**

- 3.
- ☒
- Drawing(s) (35 U.S.C. 113) Total Sheets
- 8**
-
- (Formals)

- 4.
- ☒
- Oath or Declaration Total Pages
- 3**

- a.
- ☒
- Newly executed (original)
-
- b.
- ☐
- Copy from a prior application (37 C.F.R. §1.63(d))
-
- (for continuation / divisional w/ box 16 completed)
-
- i.
- ☐
- DELETION OF INVENTOR(S)
-
- Signed statement attached deleting inventor(s) named in
-
- the prior application, see 37 C.F.R. §1.63(d)(2) and
-
- 1.33(b).

- 5.
- ☐
- CD-ROM or CD-R in duplicate, large table or Computer
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- Program (Appendix)

- 6.
- ☐
- Nucleotide and/or Amino Acid Sequence Submission
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- a.
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- Computer Readable Form (CRF)
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- b. Specification or Sequence Listing on:
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- i.
- ☐
- CD-ROM or CD-R (2 copies); or
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- ☐
- Statements verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

- 7.
- ☒
- Assignment Papers (cover sheet & document(s))
-
- 8.
- ☐
- Application Data Sheet. See 37 CFR 1.76
-
- 9.
- ☐
- 37 C.F.R. §3.73(b) Statement
- ☐
- Power of Attorney
-
- (when there is an assignee)
-
- 10.
- ☐
- English Translation Document (if applicable)
-
- 11.
- ☒
- Information Disclosure
-
- Statement (IDS)/PTO-1449
- ☒
- Copies of IDS (7)
-
- Citations
-
- 12.
- ☐
- Preliminary Amendment
-
- 13.
- ☒
- White Advance Serial No. Postcard
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- 14.
- ☐
- Certified Copy of Priority Document(s)
-
- (if foreign priority is claimed)
-
- 15.
- ☐
- Applicant claims small entity status.
-
- See 37 CFR 1.27
-
- 16.
- ☒
- Other: Notice of Priority, Statement or Relevancy

16. If a CONTINUING APPLICATION, check appropriate box, and supply the requisite information below:

☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application no.:

Prior application information: Examiner:

Group Art Unit:

For CONTINUATION OR DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 4b, is considered a part of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

17. Amend the specification by inserting before the first line the sentence:

☐ This application is a ☐ Continuation ☐ Division ☐ Continuation-in-part (CIP)
of application Serial No. Filed on☐ This application claims priority of provisional application Serial No. Filed

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Docket No. 200246US2

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

INVENTOR(S) Masaki NARUSHIMA

SERIAL NO: New Application

FILING DATE: Herewith

FOR: CERAMIC HEATER SYSTEM AND SUBSTRATE PROCESSING APPARATUS HAVING THE SAME
INSTALLED THEREIN

FEE TRANSMITTAL

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FOR	NUMBER FILED	NUMBER EXTRA	RATE	CALCULATIONS
TOTAL CLAIMS	22 - 20 =	2	× \$18 =	\$36.00
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Respectfully Submitted,

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TITLE OF THE INVENTION

CERAMIC HEATER SYSTEM AND SUBSTRATE PROCESSING
APPARATUS HAVING THE SAME INSTALLED THEREIN

CROSS-REFERENCE TO RELATED APPLICATIONS

5 This application is based upon and claims the
benefit of priority from the prior Japanese Patent
Application No. 11-341916, filed December 1, 1999, the
entire contents of which are incorporated herein by
reference.

10 BACKGROUND OF THE INVENTION

 The present invention relates to ceramic heater
system which heats a substrate in treatments, such as
CVD (Chemical Vapor Deposition) and plasma etching, and
to a substrate processing apparatus having this heater
15 system installed therein.

 The general fabrication of semiconductor devices
includes a step of performing a vacuum treatment, such
as CVD or plasma etching, on a semiconductor wafer to
be processed. In such a treatment, a heat treatment
20 for heating a semiconductor wafer to a predetermined
temperature is carried out. To execute such a heat
treatment, a heater is buried in a substrate support
member. A typical conventional heater of this type is
a stainless heater.

25 Ceramic heaters that are hard to be corroded by
halogen-base gases which are used in processing
semiconductor wafers and have a high heat exchanging

efficiency have been developed recently and are becoming popular. Such a ceramic heater has a heat generating wire of a high-melting-point metal buried in a heater base which is a dense ceramic sintered body of AlN or the like and on the top of which a semiconductor wafer is to be mounted.

A heat treatment which is executed at the time of performing CVD, plasma CVD or the like is demanded of an extremely high uniform heating performance while heating a semiconductor wafer to 500°C or higher.

Further, it is required that semiconductor wafers should be resistant to plasma during plasma etching.

Because it is difficult to provide the desired uniform heating by a ceramic heater alone, which is buried in the heater base, various schemes are attempted to achieve the uniform heating. For example, the technique that is disclosed in Jpn. Pat. Appln. KOKAI Publication No. 272834/1995 has a fluid passage with a fine cross-sectional area provided between a semiconductor-wafer mounting surface of a ceramic heater base and a buried heater. The temperature differences at individual positions of the ceramic heater base are therefore reduced by the convection of a fluid flowing in the fluid passage, thereby ensuring a uniform heating temperature on the mounting surface.

There are demands for further improvement of the throughput in the fabrication of semiconductor devices

is demanded of and for a shorter down time at the time of maintenance of the substrate processing apparatus.

For example, a single wafer type CVD system regularly executes in-situ cleaning with a halogen-base gas and needs to lower the temperature of a ceramic heater to 150 to 500°C from a film deposition temperature of 700°C. As the conventional cooling time is about 3 hours, a shorter cooling time is demanded. The interior of the chamber is exposed to the atmosphere for maintenance or the like. The interior of the chamber is cooled to near the room temperature to facilitate the maintenance. The cooling requires a long time. It is demanded that the cooling be achieved within a short time.

The aforementioned technique disclosed in Jpn. Pat. Appln. KOKAI Publication No. 272834/1995 can cool the heater base by the flow of the fluid at the time of maintaining the processing apparatus that uses the ceramic heater. This can shorten the down time in which the apparatus is stopped.

Generally speaking, to provide a sufficient cooling performance, the cross-sectional area of the fluid passage should be increased to permit the flow of a larger amount of fluid to carry the heat out. This technique has been developed to mainly ensure uniform heating and does not provide a sufficient cooling performance. Since the technique is intended

to make the heating temperature on the mounting surface even, however, it is necessary to avoid deterioration of the heating efficiency. This is achieved by preventing the heat transmission from the heater to the mounting surface from becoming lower, and requires that
5 the cross-sectional area of the fluid passage be made as small as possible.

Therefore, the more the heating efficiency is improved, the less the performance of the cooling means
10 for the heater becomes sufficient. The conventional technique suffers a limitation to shortening the time of cooling the heater base and faces a difficulty in satisfying the demanded short cooling time.

BRIEF SUMMARY OF THE INVENTION

15 Accordingly, it is an object of the present invention to provide a ceramic heater system which has a high cooling efficiency while keeping the uniform heating performance on the heating surface high, and a substrate processing apparatus in which this ceramic
20 heater system is installed.

A ceramic heater system according to this invention comprises a ceramic heater base having a substrate mounting surface formed on a top surface thereof; a heater, buried in the heater base, for
25 heating a substrate; and a fluid passage provided in the heater base below the heater, whereby the heater base is cooled by letting a fluid whose temperature is

lower than a temperature of the heater base flow in the fluid passage.

A substrate processing apparatus in which such a ceramic heater system is installed comprises a chamber whose interior can be kept in a vacuum state by an exhaust system and processing means for performing a predetermined treatment on the substrate in the chamber, and performs film deposition and etching on the substrate.

Additional objects and advantages of the invention will be set forth in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and obtained by means of the instrumentalities and combinations particularly pointed out hereinafter.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate presently preferred embodiments of the invention, and together with the general description given above and the detailed description of the preferred embodiments given below, serve to explain the principles of the invention.

FIG. 1 is a vertical cross-sectional view exemplarily illustrating a ceramic heater system according to a first embodiment of the present

invention;

FIG. 2 is a horizontal cross-sectional view along the line A-A in FIG. 1;

FIG. 3 is a cross-sectional view illustrating a ceramic heater system according to a second embodiment;

FIG. 4 is a cross-sectional view showing a ceramic heater system according to a modification of the second embodiment;

FIG. 5 is a cross-sectional view showing a ceramic heater system according to a third embodiment;

FIG. 6 is a cross-sectional view showing a ceramic heater system according to a modification of the third embodiment;

FIG. 7 is a cross-sectional view showing a ceramic heater system according to a fourth embodiment;

FIG. 8 is a cross-sectional view showing a ceramic heater system according to a fifth embodiment;

FIG. 9 is a horizontal cross-sectional view along the line B-B in FIG. 8;

FIGS. 10A and 10B are cross-sectional views depicting a ceramic heater system according to a sixth embodiment;

FIGS. 11A and 11B are cross-sectional views depicting a ceramic heater system according to a first modification of the sixth embodiment;

FIGS. 12A and 12B are cross-sectional views depicting a ceramic heater system according to a second

modification of the sixth embodiment;

FIG. 13 is a cross-sectional view of a thermal CVD system which uses a ceramic heater system 32 embodying the invention;

5 FIG. 14 is a cross-sectional view of a plasma CVD system which uses a ceramic heater system embodying the invention; and

FIG. 15 is a cross-sectional view showing a plasma etching system which uses a ceramic heater system
10 embodying the invention.

DETAILED DESCRIPTION OF THE INVENTION

Preferred embodiments of the present invention will now be described with reference to the accompanying drawings.

15 FIG. 1 is a vertical cross-sectional view exemplarily illustrating a ceramic heater system for processing a semiconductor wafer according to the first embodiment of the invention. FIG. 2 is a horizontal cross-sectional view taken along the line A-A in
20 FIG. 1.

A ceramic heater system 1 has a disk-shaped heater base 2 of ceramics and a heating resistive element (heater) 3 buried in the heater base 2 in a coil form. A fluid passage 4 is provided in the heater base 2
25 below the heater 3.

Any dense ceramics may be used for the heater base 2. Preferable ceramics for the heater base 2

include nitride ceramics, such as silicon nitride (Si_3N_4), aluminum nitride (AlN) and silicon aluminum oxy nitride (SiAlON), and aluminum oxide (Al_2O_3).

The top surface of the heater base 2 serves as
5 a mounting surface 2a for a semiconductor wafer W.

The heater 3, which is a heat resistor, is buried in the heater base 2 in a predetermined pattern (e.g., a spiral form) with its both end portions connected to terminals 5 buried in the vicinity of the peripheral
10 portion of the bottom of the heater base 2. The heater 3 is connected to a power supply 6 by wires that run from the terminals 5. The output of the power supply 6 is controlled by a controller 7 based on a detection signal from an unillustrated thermocouple provided
15 on the heater base 2. The semiconductor wafer W is thereby heated to the desired temperature. The heater 3 is formed of metal, and can be a nichrome wire when the heating temperature is relatively low. For a high-temperature ceramic heater, however,
20 a high-melting-point metal is preferable. A particularly preferable metal is tungsten (W), molybdenum (Mo), platinum (Pt) or an alloy of the mentioned metals.

As shown in FIG. 2, the fluid passage 4 has
25 a plurality of annular portions 4a concentric to the heater base 2, and radial portions 4b which radially link adjoining annular portions 4a at four locations.

The radial portions 4b that are adjacent to one another in the peripheral direction are arranged at equidistances of 90° , while the radial portions 4b that are adjacent to one another in the radius direction are shifted by 45° from one another. Preferably, the radial portions 4b are interposed between the annular portions 4a. In this case, the radial portions 4b do not overlap the annular portions 4a. In the fluid passage, the annular portions 4a and radial portions 4b are arranged so that semiconductor wafers may be heated and cooled with high efficiency. A fluid supply hole 9, through which a fluid is supplied into the fluid passage 4, is formed in the center of the heater base 2. Two fluid discharge holes 8 are formed at opposite positions of the outermost annular portion 4a.

Moreover, the holes connecting any two adjacent circular portions are arranged at regular intervals along either circular portion. Each hole made in one of walls defining a circular portion opens to that part of the other wall of the circular portion, which is located between two adjacent holes made in the other wall of the circular portion.

Designing the fluid passage 4 this way ensures effective heat exchange and a high cooling efficiency. A fluid supply pipe 9a is connected to the fluid supply hole 9, and fluid discharge pipes 8a to the fluid discharge holes 8. Those pipes 8a and 9a are

connected to a fluid supply source 10 so that the fluid is circulated by an unillustrated pump or similar means. The temperature of the gas that is supplied from the fluid supply source 10 is adjusted to a
5 predetermined temperature by a temperature adjuster 11. This makes it possible to maintain the uniform heating of the heater base 2 and perform cooling control on the heater base 2. A heat exchanger 12 is connected to the fluid discharge pipes 8a so as to be able to remove
10 the extra heat of the fluid that has become hot by the high-temperature heater base 2.

It is preferable that the temperature of the fluid which is let flow in the fluid passage 4 be approximately in a range of -10 to 800°C . In the case
15 where a low-temperature fluid flows in the fluid passage 4, the ceramic heater base 2 may be damaged by a heat shock. It is therefore preferable to reduce the temperature of the fluid step by step by the temperature adjuster 11 in accordance with the heating
20 temperature of the heater base 2 so that the excellent cooling efficiency is acquired within the range where heat-shock originated damages can be avoided. The step-by-step temperature reduction is accomplished by, for example, always setting the temperature of the
25 fluid to a temperature lower than the temperature of the heater base 2 at equi-intervals from 100°C to 200°C and adequately lowering the temperature of the fluid

when the temperature of the heater base 2 drops.

While a gas or a liquid is available as the fluid, it is preferable to use an inactive gas in consideration of possible leakage of the fluid in the chamber against a possible damage in the heater base 2. Of course, the fluid is not limited to a gas. Preferable gases are inert gases available, such as Ar, He, Ne and N₂ gases, at least one of which is selectively used or a proper combination of which is used. One preferable combination is a mixed gas of Ar and He. This is because the combination of high-cost He, which has a high thermal conductivity and low-cost Ar, can ensure the adequate cooling cost performance while keeping a relatively high cooling efficiency. From this point of view, the ratio of Ar to He is preferably 3 : 1. Alternatively, the ratio of He to Ar is 20% or more.

To use the ceramic heater system 1 thus constituted, power is supplied to the heater 3 from the power supply 6 with a semiconductor wafer W placed on the mounting surface 2a or the top surface of the heater base 2. This raises the temperature of the heater base 2 to a predetermined temperature under the control of the controller 7, thus heating the semiconductor wafer W to the predetermined temperature. As a predetermined fluid, such as a gas selected from, for example, Ar, He, Ne and N₂, is let flow in the

fluid passage 4 at a predetermined flow rate at this time, the temperature controllability becomes higher so that the heater base 2 can keep the desired uniform heating performance.

5 At the time of cooling the ceramic heater system 1 down from the heating temperature, the fluid is let flow in the fluid passage 4 after power supply to the heater 3 is cut off. According to this embodiment, the heating efficiency does not decrease even if the
10 cross-sectional area of the fluid passage 4, which differs from the fluid passage in the prior art that is located above the heater, is increased. Accordingly, the cross-sectional area of the fluid passage 4 increases, permitting a relatively large amount of
15 fluid to flow inside. The ceramic heater system 1 is therefore cooled to a predetermined temperature in a short period of time.

 A ceramic heater system according to the second embodiment of the invention will now be discussed with
20 reference to FIG. 3 which shows the cross section of the ceramic heater system. To avoid the detailed description, like or same reference numerals are given to those components of the second embodiment which are the same as the corresponding components shown in
25 FIG. 1. Like the first embodiment shown in FIG. 1, the second embodiment has a fluid supply source 10, a temperature adjuster 11 and a heat exchanger 12, though

these components are not shown in FIG. 3. Likewise,
all other embodiments, but the fifth embodiment
(FIGS. 4 to 7, FIGS. 10 to 12), have a fluid supply
source 10, a temperature adjuster 11 and a heat
5 exchanger 12, though these components are not shown for
the simplicity of drawings.

In the ceramic heater system of the second
embodiment, a heater 13 buried in the heater base 2 is
formed of graphite or glassy carbon and is arranged in
10 a predetermined pattern (e.g., a spiral form).

In the ceramic heater system, the coefficients
of thermal expansion of graphite and glassy
carbon, materials for the heater 13, are respectively 2
to $3 \times 10^{-6}/K$ and $1.5 \times 10^{-6}/K$ to $2.5 \times 10^{-6}/K$, which
15 are relatively close to the coefficient of thermal
expansion of AlN of $4.6 \times 10^{-6}/K$, so that the heater
base 2 can be used without being damaged even if the
temperature is raised fast or dropped fast.

As a modification of the second embodiment shown
20 in FIG. 4, a heater 13a having a core 14 of graphite or
glassy carbon coated with a glassy BN layer 15 may be
used. In this case, the glassy BN has a function of
protecting the core 14 of graphite or glassy carbon and
a buffer capability, thus ensuring faster temperature
25 raising and faster temperature drop.

A ceramic heater system according to the third
embodiment of the invention will now be discussed with

reference to FIG. 5, which shows the cross section of the ceramic heater system. To avoid the detailed description, like or same reference numerals are given to those components of the third embodiment which are the same as the corresponding components shown in FIG. 1.

According to this embodiment, an electrode 20 is provided between the heater 3 of the heater base 2 and the mounting surface 2a and a DC power supply 21 for applying a voltage to the electrode 20 is connected to the heater 3 via a terminal 22. The DC power supply 21 may be replaced by a high-frequency power supply. This structure forms electrostatic chuck on the upper surface portion of the heater base 2.

As a DC voltage is applied to the electrode 20 in the ceramic heater system, a semiconductor wafer W to be mounted is electrostatically chucked to the mounting surface 2a of the heater base 2. This allows the semiconductor wafer W to be surely held even when the heater base 2 is used in the vacuum atmosphere. This embodiment can provide a compact structure which has the electrostatic chuck integrated with the ceramic heater.

Needless to say, an electrode may be provided at a similar position in the heater bases whose structures are illustrated in FIGS. 3 and 4 to add an electrostatic chuck capability.

In the case where a plasma treatment is carried out by using the ceramic heater of each of the above-described embodiments, a plasma-producing electrode 23 is buried in the heater base 2 as in a modification of the third embodiment shown in FIG. 6. Plasma can be produced by grounding the electrode 23 and applying high-frequency power to the opposing electrode in the vacuum atmosphere. A DC voltage is applied to the electrode provided below the counter electrode. The DC voltage functions as a bias introducing ions and flakes into the substrate. The etching rate and the deposition rate are thereby enhanced.

High-frequency power may be applied to the electrode 23. Instead of ground the electrode 23, a DC voltage may be applied to the electrode 23 so that the electrode 23 also serves as an electrode for the electrostatic chuck.

A ceramic heater system according to the fourth embodiment of the invention will now be described with reference to FIG. 7 which shows the cross section of the ceramic heater system. To avoid the detailed description, like or same reference numerals are given to those components of the fourth embodiment which are the same as the corresponding components shown in FIG. 1.

In this embodiment, a heater base 24 is separated into two portions at the bottom surface of the fluid

supply passage 4: an upper heater base 24a in which the heater 3 is buried and a lower heater base 24b in which the fluid supply hole 9 and the fluid discharge holes 8 are formed. The upper heater base 24a and the lower heater base 24b are securely adhered together by an adhesive to be discussed later direct bond, ceramic, screws or the like. Alternatively, the upper and lower heater bases 24a and 24b may be made integral by a holder or the like which supports those heater bases 24a and 24b from the side while tightly connecting them. Such an integral structure makes the fluid passage 4 airtight.

An electrode may be provided in such a way as to add an electrostatic chuck capability in the fourth embodiment too.

According to this embodiment, the separation of the heater base 24 into two parts can facilitate the formation of the fluid passage 4.

According to the ceramic heater systems of the above-described embodiments, the fluid passage is provided below the heater. Thus, the heating efficiency of the heater to heat a semiconductor wafer does not fall even if the cross-sectional area of the fluid passage is increased. Therefore, the cross-sectional area of the fluid passage can be increased to supply a relatively large amount of fluid, thereby to cool the heater base in a short period of time.

Even the provision of the fluid passage below the heater can ensure the desired uniform heating performance.

5 It is preferable that the fluid passage should be designed to have a plurality of concentric circular portions and a plurality of portions which link those concentric circular portions. Further, it is preferable that the fluid passage should have a fluid inlet formed in the center portion of the heater base and fluid outlets formed at end portions of the heater base. The fluid inlet can be provided at a position that is optimal in view of the positions of the heater power supply and the terminals of the temperature sensor. This structure can improve the uniform heating performance and the cooling efficiency.

10

15

The temperature of the fluid which flows in the fluid passage is variable within a range of -10 to 800°C and preferably within a range of about 150 to 500°C . Of course, the temperature of the fluid can be changed in accordance with the conditions of the process. A fluid whose temperature is equal to or lower than 150°C may be used in the case of exposing the interior of the chamber to the air for the purpose of maintenance.

20

25 In the case of causing a low-temperature fluid to flow in the fluid passage to cool the ceramic heater base, the temperature of the fluid should be set

properly in accordance with the temperature of the heater base to prevent the heater base from being damaged by a heat shock. Specifically, the temperature of the fluid is equal to or lower than about 75% of the temperature of the heater base to be cooled. It is preferable that the temperature of the fluid should be reduced step by step in accordance with the cooling stage of the heater base. When the heater base is very hot, for example, heat-shock originated damages can be prevented by always adjusting the temperature of the fluid lower than the temperature of the heater base by 100 to 200°C. In the case of exposing the interior of the chamber to the air, the heater base can be cooled down efficiently if the temperature of the fluid is set lower when the temperature of the heater base drops close to 150°C.

FIG. 8 is a vertical cross-sectional view showing a ceramic heater system for processing a semiconductor wafer according to the fifth embodiment of the invention. FIG. 9 is a horizontal cross-sectional view taken along the line B-B in FIG. 8. To avoid the detailed description, like or same reference numerals are given to those components of the fifth embodiment which are the same as the corresponding components shown in FIG. 1.

In this embodiment, a heater base 25 is separated into two portions at the bottom surface of the fluid

passage 4. That is, an upper heater base 25a in which the heater 3 is buried, and a lower heater base 25b in which the fluid supply hole 9 is formed. As shown in FIG. 9, fluid discharge holes 26 are formed sideways

5 in the upper heater base 25a so that the fluid is discharged into the chamber. The lower heater base 25b is provided with the fluid source 10 which supplies the fluid and the temperature adjuster 11 which adjusts the temperature of the fluid. This structure of

10 the embodiment causes the fluid to be discharged into the chamber, eliminating the need for the flow route from the fluid passage 4 to the heat exchanger 12 and thus the heat exchanger 12. The structure is simpler than the structure of the above-described embodiments

15 in which the fluid is circulated in an airtight manner in the cycle of the fluid source 10 to the temperature adjuster 11 to the fluid passage 4 to the heat exchanger 12 while the temperature of the fluid is being adjusted. However, in the structure of the fifth

20 embodiment, some kind of fluid should flow in the fluid passage 4 any time including during the processing of the semiconductor wafer in order to prevent the gas in the chamber from entering the fluid passage 4. The upper heater base 25a and the lower heater base 25b may

25 be adhered integrally in the same way as mentioned in the foregoing description of the fourth embodiment. Further, an electrode may also be provided in the fifth

embodiment to add an electrostatic chuck capability.

According to this embodiment, the separation of the heater base 25 into two parts can facilitate the formation of the fluid passage 4. As the fluid is discharged into the chamber, the structure becomes simpler.

FIG. 10A shows the horizontal cross section of a part of the heater base of a ceramic heater system for processing a semiconductor wafer according to the sixth embodiment. FIG. 10B shows the vertical cross section of a portion M shown in FIG. 10A. The illustrated example is adapted to the heater bases 24a and 25a of the fourth and fifth embodiments.

To improve the cooling efficiency, cooling fins 27 are provided on the heater-side surface of the fluid passage 4. The provision of the cooling fins 27 can increase the thermal conductivity to the fluid. Although two cooling fins 27 are shown, the number of the cooling fins is not limited to this quantity and a greater number of the cooling fins may be provided.

FIGS. 11A and 11B show a first modification of the sixth embodiment in which cooling fins 28 are provided on the surfaces of the fluid passage 4 perpendicular to the heater's side surfaces at positions relatively close to the heater. The cooling fins 28 demonstrate the same effect as the cooling fins 27 of the sixth embodiment. FIGS. 12A and 12B shows a second

modification of the sixth embodiment in which the fluid passage has a irregularity surface with multiple crating and undulations. The irregularity surface increases the surface area to thereby increase the thermal conductivity to the fluid.

This embodiment is not limited to the provision of the aforementioned cooling fins or irregularity surface, but the heater-side surface of the fluid passage 4 may be designed in any shape as long as the surface area of the fluid passage 4 is increased. For example, the heater-side surface of the fluid passage 4 may have a irregularity surface of a sawtooth shape to improve the thermal conductivity to the fluid.

A description will now be given of a method of producing such a heater base.

First, a ceramic powder is put in a mold set in a press-molding machine and premolding is performed. Then, a continual recess is provided on the surface of the premolded article in accordance with the heater pattern. Next, the heater with terminals connected to both ends is retained in the recess, a ceramic powder is further put in the recess and is subjected to unconfined press molding, thus molding a disk-shaped article. The obtained article is sintered by hot pressing or the like, thus molding a first presintered body.

Subsequently, a ceramic powder is likewise

subjected to unconfined press molding, thus molding
a disk-shaped article, which is in turn sintered by
hot pressing or the like, thus molding a second
presintered body. Then, a groove corresponding to
5 the fluid passage is made in the top surface of
the second presintered body by an adequate method, such
as sand blasting or etching. Further, a fluid supply
hole and fluid discharge holes are formed. Finally,
the first presintered body and the second presintered
10 body are adhered hot direct bond by using an adhesive
of glass, such as YSiAlON-based glass. While it is
preferable to perform sintering by hot pressing,
atmospheric pressure sintering may be used as well.
Hot isostatic pressing (HIP) may be executed after
15 atmospheric pressure sintering.

A description will now be given of a substrate
processing apparatus in which a ceramic heater system
having the above-described structure is installed.

FIG. 13 is a cross-sectional view of a thermal CVD
20 system which uses a ceramic heater system 32 embodying
the invention. This thermal CVD system 30 has a nearly
cylindrical chamber 31 designed in an airtight manner.
A semiconductor wafer W, a work to be processed, is
supported horizontally in the chamber 31 and the
25 ceramic heater system 32 which heats the semiconductor
wafer W is supported on cylindrical support members 33.
Provided on the peripheral edge of the heater base 2 is

a guide ring 34 for guiding the semiconductor wafer W.

The ceramic heater system 32 is constructed in quite the same way as the ceramic heater system 1 shown in FIG. 1. That is, the heater 3 is buried in the ceramic heater base 2 and the fluid passage 4 is provided below the heater 3. Both end portions of the heater 3 are connected to the terminals 5 buried in the vicinity of the peripheral portion of the bottom of the heater base 2. The wires extending from the terminals 5 run inside the support members 33 to be connected to the power supply 6 whose output is controlled by the controller 7.

A shower head 35 is provided on a ceiling 31a of the chamber 31. Multiple gas discharge holes 36 for discharging a gas toward the semiconductor wafer W in the ceramic heater system 32 are formed in the shower head 35. A gas inlet 37 is formed in the upper portion of the shower head 35. The gas inlet 37 is connected to a cleaning-gas feeding mechanism 39 and a process-gas supply mechanism 40 via a gas feeding pipe 38.

The cleaning-gas supply mechanism 39 has a cleaning gas source for supplying a ClF_3 gas, for example, as a cleaning gas, so as to ensure regular in-situ cleaning of the interior of the chamber 31. The process-gas supply mechanism 40 has, for example, a TiCl_4 gas source, NH_3 gas source, Ar gas (dilution gas) source and so forth in the case where a film to be

deposited is a TiN film, or has a WF_6 gas source, SiH_2Cl_2 gas source, Ar gas source and so forth in the case where a film to be deposited is a WSi film.

5 Connected to a bottom wall 31b of the chamber 31 is an exhaust pipe 41 which is connected to an exhaust system 42 including a vacuum pump. As the exhaust system 42 is activated, the interior of the chamber 31 can be depressurized to a predetermined degree of vacuum.

10 To deposit a predetermined thin film on the semiconductor wafer W using this substrate processing apparatus, first, the semiconductor wafer W is loaded into the chamber 31 and is placed on the mounting surface 2a of the ceramic heater system 32. The
15 chamber 31 is discharged to the vacuum state by the exhaust system 42. Then, the heater base 2 is heated by the heater 3 up to, for example, about 500 to 700°C, thereby heating the overlying semiconductor wafer W to a predetermined temperature. Then, the process gas is
20 supplied into the chamber 31 from the process-gas supply mechanism 40 via the gas feeding pipe 38 and film deposition is performed while keeping the internal pressure of the chamber 31 to a predetermined pressure.

25 In this case, the temperature controllability is enhanced by feeding a gas selected from, for example, Ar, He, Ne and N_2 , allowing the heater base 2 to keep the desired uniform heating performance.

After film deposition is carried out on a predetermined number of semiconductor wafers W in this manner, the semiconductor wafers are removed from the chamber 31 and the ceramic heater system 32 is cooled to about 150 to 500°C. Then, the cleaning gas, e.g., ClF_3 gas, is supplied into the chamber 31 to perform in-situ cleaning of the chamber 31. At this time, the fluid is let flow in the fluid passage 4 after power supply to the heater 3 is cut off. In this case, the cross-sectional area of the fluid passage 4 can be increased to permit the flow of a relatively large amount of fluid. The ceramic heater system 32 can therefore be cooled to 150 to 500°C in a short period of time. In the case of exposing the interior of the chamber 31 to the air for the purpose of maintenance or the like, the internal temperature in the chamber 31 should be reduced to near the room temperature. The temperature can be lowered so in a short period of time.

FIG. 14 is a cross-sectional view of a plasma CVD system which uses a ceramic heater system embodying the invention.

While the schematic structure of this plasma CVD system 50 is similar to the structure of the thermal CVD system shown in FIG. 13, the plasma CVD system 50 has an insulating member 43 provided between the ceiling 31a and a side wall 31c of the chamber 31 with

the ceiling 31a connected via a matching circuit 44 to a high-frequency power supply 45. As high-frequency power of, for example, 13.56 MHz is supplied to the shower head 35 from the high-frequency power supply 45, the shower head 35 serves as an upper electrode.

A lower electrode 51 for producing plasma is buried in the heater base 2 of the ceramic heater system 32 above the heater 3. A DC power supply 53 is connected via a terminal 52 to the lower electrode 51 which also serves as an electrostatic chuck electrode. The plasma CVD system 50 deposits, for example, a Ti film.

In this case, the process-gas supply mechanism 40 has, for example, a TiCl_4 gas source, H_2 gas source, Ar gas (dilution gas) source and so forth. The other structure is the same as the thermal CVD system shown in FIG. 13, so that to avoid the redundant description, like or same reference numerals are given to the corresponding components.

To deposit a predetermined thin film on the semiconductor wafer W using this substrate processing apparatus, first, the semiconductor wafer W is loaded into the chamber 31 and is placed on the mounting surface of the ceramic heater system 32.

Then, the heater base 2 is heated by the heater 3 up to, for example, about 500 to 700°C to heat the overlying semiconductor wafer W to a predetermined

temperature. While the semiconductor wafer W is being heated up, the chamber 31 is discharged to the vacuum state by the exhaust system 42.

Then, the process gas is supplied into the chamber 31 from the process-gas supply mechanism 40 via the gas feeding pipe 38 and high-frequency power is supplied to the shower head 35 that serves as the upper electrode from the high-frequency power supply 45. As a result, a high-frequency electric field is produced between the shower head 35 and the electrode 23 and plasma is produced in the process-gas containing atmosphere.

At this time, a DC voltage is applied to the electrode 51 from the DC power supply 52 so that the semiconductor wafer W is electrostatically chucked on the surface of the heater base 2. Because the volume resistance of the heater base 2 varies in accordance with the temperature when such electrostatic capability is provided, the material whose resistance indicates an electrostatically chuckable property at the heating temperature is used for the heater base 2. In this case, the temperature controllability is enhanced by feeding a gas selected from, for example, Ar, He, Ne and N₂, allowing the heater base 2 to have the desired uniform heating performance.

After film deposition is carried out on a predetermined number of semiconductor wafers W, the semiconductor wafers are carry out from the chamber 31

and the ceramic heater system 32 is cooled to about 150 to 500°C, preferably to 200 to 300°C, to perform in-situ cleaning of the chamber 31, as done in the case of plasma CVD.

5 As described above, the cross-sectional area of the fluid passage 4 is increased, permitting the flow of a relatively large amount of fluid. The ceramic heater system 32 can therefore be cooled to 150 to 500°C quickly. The internal temperature of the chamber 31
10 can be lowered to room temperature quickly by exposing the interior of the chamber 31 to the atmosphere for the purpose of maintenance or the like.

FIG. 15 is a cross-sectional view showing a plasma etching system which uses a ceramic heater system
15 embodying the invention.

While the schematic structure of the plasma etching system 60 is similar to the structure of the plasma CVD system shown in FIG. 15, an etching-gas supply mechanism 61 is provided in place of the
20 process-gas supply mechanism 40 because an etching gas is supplied. The etching gas, which varies depending on a film to be etched, may be a fluorine-contained gas, such as CF₄ gas, and the etching-gas feeding mechanism 61 is provided with a source for such an
25 etching gas. The other structure is approximately the same as that of the plasma CVD system, so that to avoid the redundant description, like or same reference

numerals are given to the corresponding components.

According to this etching system, the temperature of the heater base 2 can be controlled to a predetermined with a high precision by the heater 3 buried in the ceramic heater system 32 and the fluid that flows in the fluid passage 4, thus permitting the temperature of the semiconductor wafer W to be uniformly kept at a predetermined temperature. In the case of exposing the interior of the chamber 31 to the air, the heater base 2 can be cooled fast by causing the fluid to flow in the fluid passage 4 provided below the heater 3. In the plasma etching system 60, high-frequency power may be supplied to the lower electrode 51 as well as the shower head 35.

Needless to say, the systems illustrated in FIGS. 13 and 15 may use the ceramic heater system of each of the above-described embodiments.

It should be apparent to those skilled in the art that the present invention is not limited to the above-described embodiments but may be modified in various other forms without departing from the spirit or scope of the invention.

For example, the shapes of the fluid passages are to be considered as illustrative and not restrictive and may take other shapes. Further, the illustrated heaters of the individual embodiments are likewise to be considered as illustrative and not restrictive and

other types may be used as well. While the typical pattern of the heater is a spiral form, it is in no way restrictive. Although the foregoing description of the individual embodiments has been given of the case where
5 the ceramic heater system of the invention is adapted to thermal CVD, plasma CVD and plasma etching, the invention is not limited to those cases but may be adapted to other treatments, such as ashing. A work to be processed is not limited to a semiconductor wafer,
10 but other substrates may be used as well.

As apparent from the foregoing description, when the ceramic heater system embodying the invention is installed in a CVD system, an etching system or the like, the down time thereof can be shortened. It is
15 also possible to ensure the desired uniform heating performance even if the fluid passage is provided below the heater.

Additional advantages and modifications will readily occur to those skilled in the art. Therefore,
20 the invention in its broader aspects is not limited to the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the spirit or scope of the general inventive concept as
25 defined by the appended claims and their equivalents.

WHAT IS CLAIMED IS:

1. A ceramic heater system-comprising:

a ceramic heater base having a substrate mounting surface formed on a top surface thereof;

5 a heater, buried in said heater base, for heating a substrate; and

a fluid passage provided in said heater base below said heater,

10 whereby said heater base is cooled by letting a fluid whose temperature is lower than a temperature of said heater base flow in said fluid passage.

2. The ceramic heater system according to claim 1, wherein said fluid passage has a plurality of concentric circular passage portions and a plurality of penetration passage portions connecting the circular
15 portions passage, and any adjacent two of the penetration passage portions are not aligned in a radial direction.

3. The ceramic heater system according to claim 2, wherein the penetration passage portions
20 connecting any two adjacent circular portions are arranged at regular intervals along either circular portion, and each penetration passage portions made in one of walls defining a circular portion opens to that
25 part of the other wall of the circular portion, which is located between two adjacent penetration passage portions made in the other wall of the circular

portion.

4. The ceramic heater system according to claim 2, wherein said fluid passage has a fluid inlet in a lower portion of said heater base and fluid outlets at end portions of said heater base.

5. The ceramic heater system according to claim 3, wherein said fluid which flows in said fluid passage is at least one gas selected from Ar, He, Ne and N₂ gases or a mixed gas thereof.

6. The ceramic heater system according to claim 5, wherein said fluid is a mixed gas of Ar and He.

7. The ceramic heater system according to claim 1, wherein a ratio of H₂ flow rate to Ar flow rate is 20% or more.

8. The ceramic heater system according to claim 1, wherein a temperature of said fluid which flows in said fluid passage ranges is adjusted to be lower than a then temperature of said heater base by 100 to 200°C.

9. The ceramic heater system according to claim 1, wherein said heater has a high-melting-point metal patterned in such a coil form as to evenly generate heat in said heater base and two zones.

10. The ceramic heater system according to claim 1, wherein said heater is formed of graphite or glassy carbon shaped in such a pattern as to evenly

generate heat in said heater base.

11. The ceramic heater system according to claim 9, wherein said heater has glassy boron nitride coated on an outer surface of graphite or glassy carbon of which said heater is formed.

12. The ceramic heater system according to claim 1, further comprising:

an electrode buried in said heater base above said heater; and

10 a DC power supply for applying a DC voltage to said electrode,

whereby applying said DC voltage to said electrode causes said substrate mounted on said mounting surface to be electrostatically chucked.

15 13. The ceramic heater system according to claim 1, further comprising:

a fluid source for supplying a fluid to said fluid passage;

20 a temperature adjuster for adjusting a temperature of said fluid supplied from said fluid source within a range of -10 to 800°C and causing said fluid to flow into said fluid passage; and

a heat exchanger for removing coarse heat of said fluid raised by said heater base,

25 whereby said fluid is circulated in a cycle of said fluid source to said temperature adjuster to said fluid passage to said heat exchanger while said

temperature of said fluid is being adjusted.

14. The ceramic heater system according to claim 1, further comprising heat-discharging fins on a heater-side surface of said fluid passage.

5 15. The ceramic heater system according to claim 1, further comprising heat-discharging fins on both side surfaces of said fluid passage with respect to a heater side and at positions closer to said heater.

10 16. The ceramic heater system according to claim 1, wherein heater-side inner surface which is said fluid passage has a roughened irregularity surface.

15 17. The ceramic heater system according to claim 2, wherein said fluid passage has a fluid inlet formed in a lower portion of said heater base and a plurality of fluid outlets formed through circumferential side walls of said heater base.

20 18. A ceramic heater system comprising:
an upper heater base of ceramics having a substrate mounting surface formed on a top surface thereof and a groove formed at a bottom surface to serve as a fluid passage;

25 a lower heater base of ceramics closely adhered to a bottom side of said upper heater base, thereby making said groove airtight; and

a heater, buried in said upper heater base, for

heating a substrate,

whereby said heater base is cooled by causing a fluid having a temperature lower than temperatures of said upper and lower heater bases to flow in said fluid passage.

19. A substrate processing apparatus comprising:
a chamber whose interior can be kept in a vacuum state by an exhaust system;

a ceramic heater system, placed in said chamber, for heating a substrate mounted thereon; and

processing means for performing a predetermined treatment on said substrate in said chamber, said ceramic heater system including,

a ceramic heater base having a substrate-mounting surface formed on a top surface thereof,

a heater, buried in said heater base, for heating said substrate, and

a fluid passage provided in said heater base below said heater, whereby said heater base is cooled by letting a fluid whose temperature is lower than a temperature of said heater base flow in said fluid passage.

20. The substrate processing apparatus according to claim 19, wherein said processing means includes:

a process-gas supply mechanism for feeding a process gas; and

a shower head, provided in said chamber at

a ceiling thereof, for introducing said process gas from said process-gas supply mechanism,

whereby a film is formed on said substrate by a reaction of said process gas.

5 21. The substrate processing apparatus according to claim 20, further comprising:

10 a high-frequency power supply, connected to said shower head, for electrically isolating said shower head and applying high-frequency power to said shower head,

15 whereby applying said high-frequency power produces plasma in said chamber with said process gas supplied inside from said shower head and said film is formed on said substrate by a reaction of said process gas with said plasma.

22. The substrate processing apparatus according to claim 19, wherein said processing means includes:

an etching-gas feeding mechanism for feeding an etching gas; and

20 an electrically isolated shower head, provided in said chamber at a ceiling thereof, for introducing said etching gas from said etching-gas supply mechanism;

25 a high-frequency power supply, connected to said shower head, for applying high-frequency power to said shower head,

whereby applying said high-frequency power produces plasma in said chamber with said etching gas

supplied inside from said shower head and said film is formed on said substrate by a reaction of said etching gas with said plasma.

ABSTRACT OF THE DISCLOSURE

A ceramic heater system has a ceramic heater base having a substrate-mounting surface formed on the top surface thereof and a heater, buried in the heater base, for heating a substrate. A fluid passage is formed buried in the heater base below where the heater is buried. The heater base is cooled as a fluid whose temperature is lower than the temperature of the heater base is let flow in the fluid passage. A substrate processing apparatus has the ceramic heater system installed in a process chamber whose vacuum state can be maintained, a gas supply mechanism for feeding a gas into the process chamber, and a power supply. The substrate processing apparatus performs a heat treatment, etching and film deposition on a substrate placed in the process chamber.

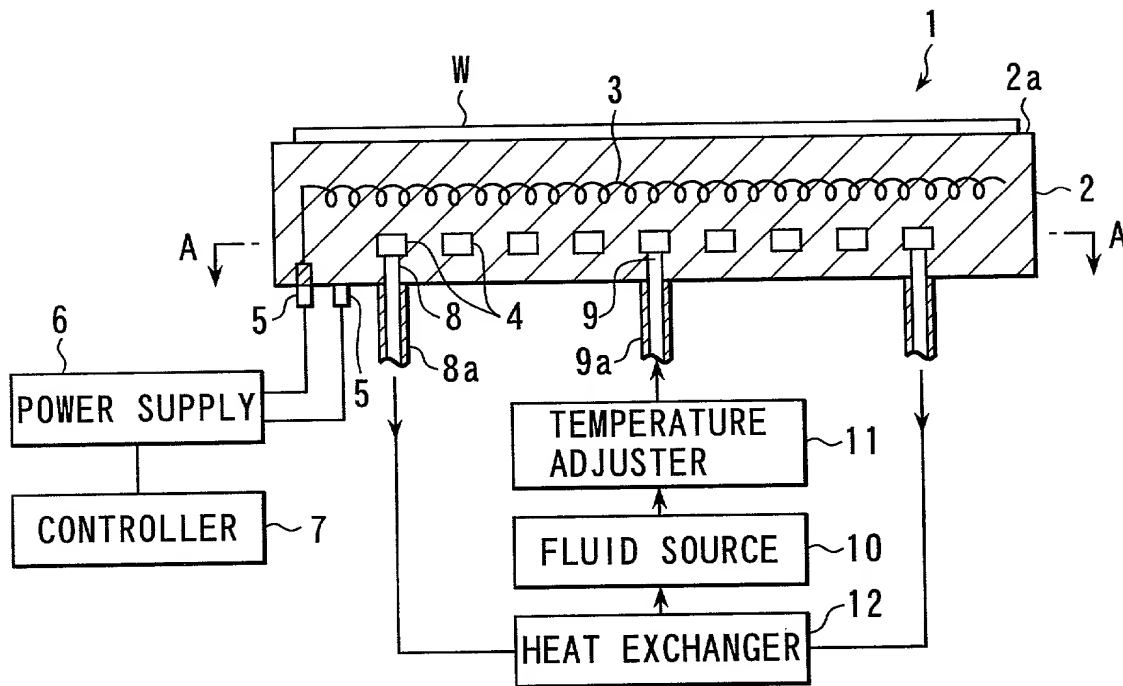


FIG. 1

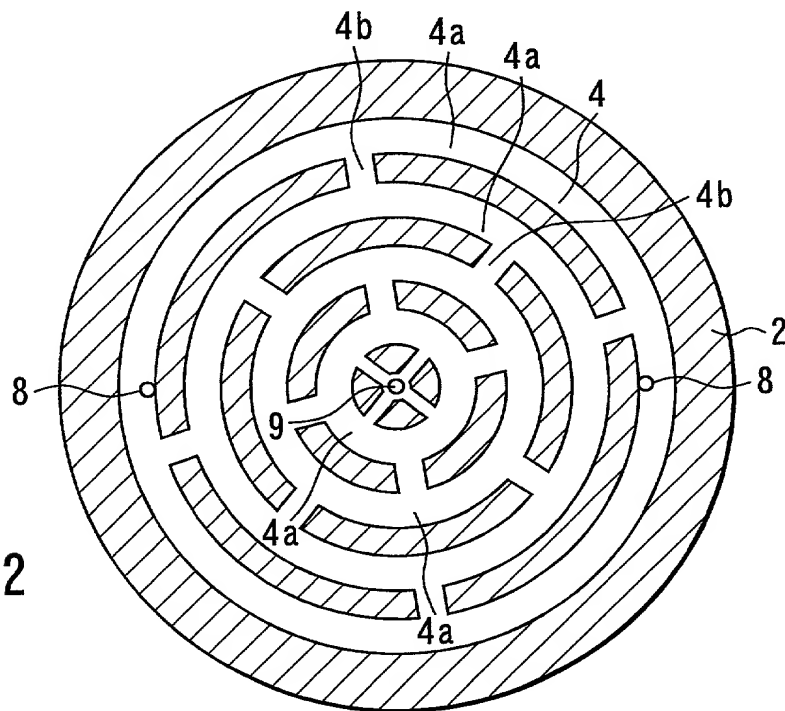
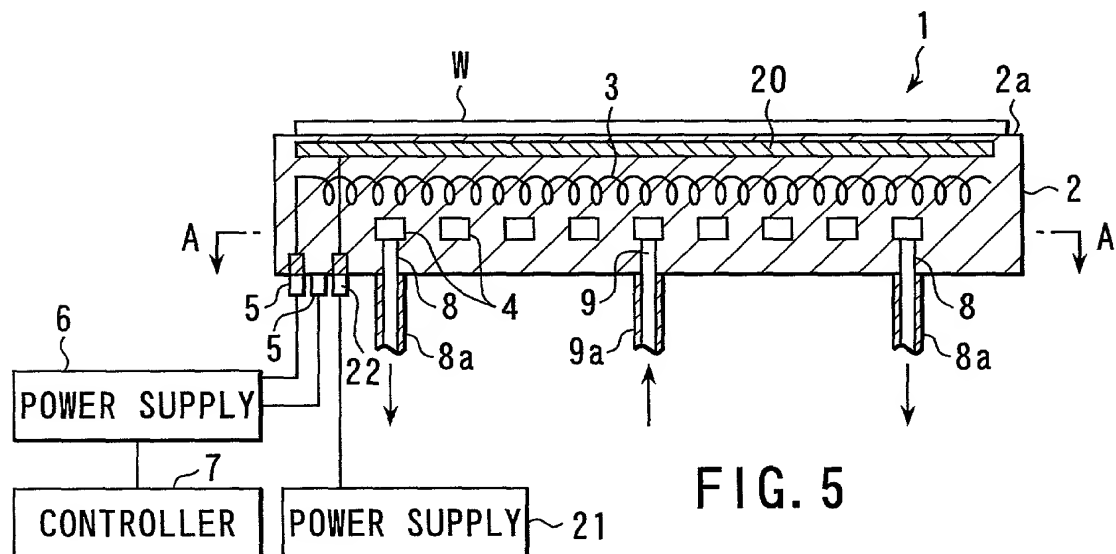
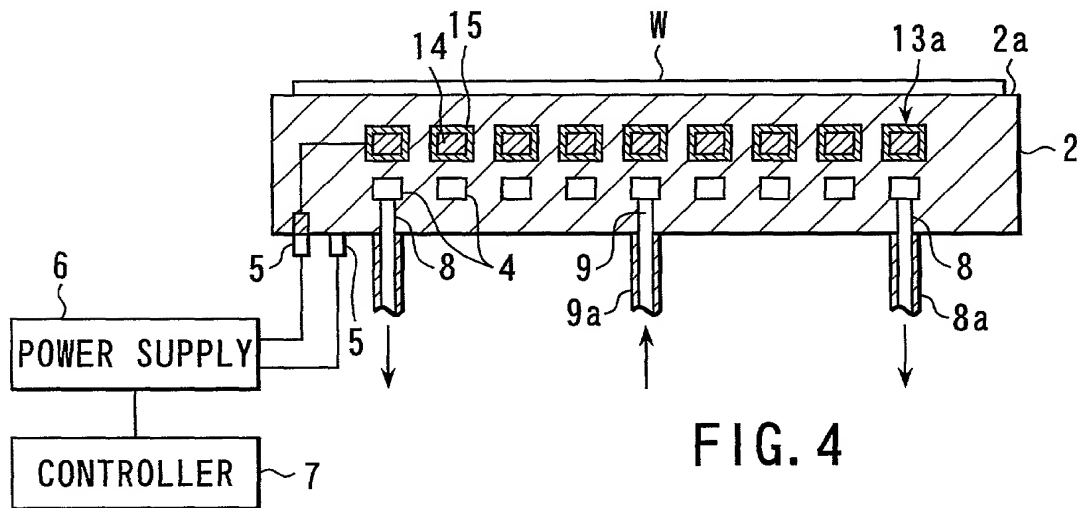
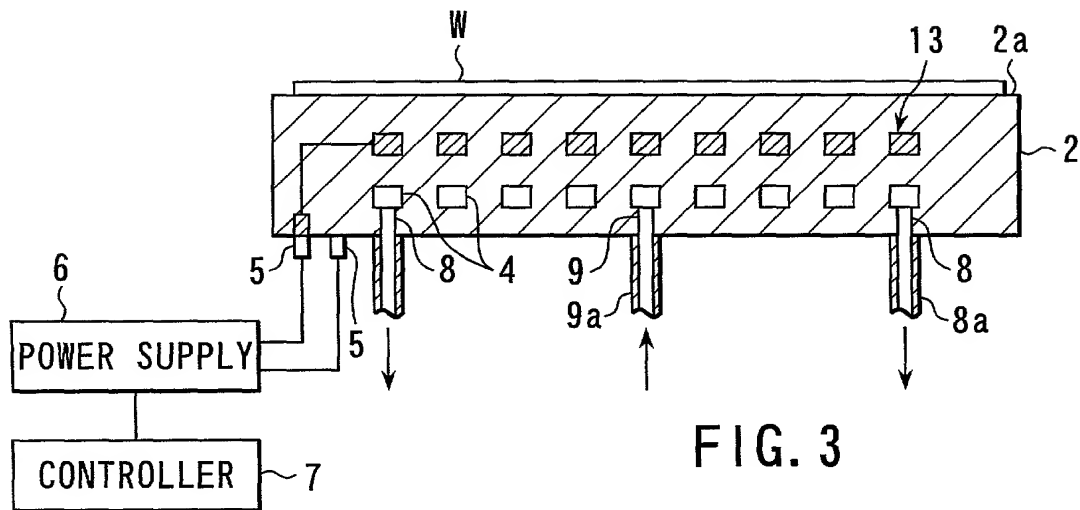
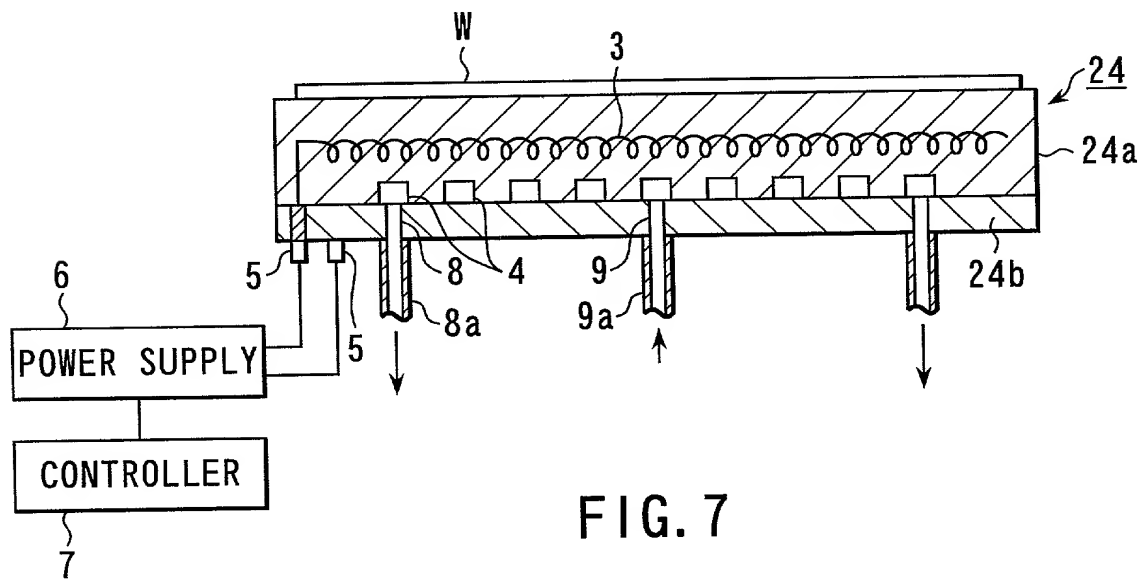


FIG. 2





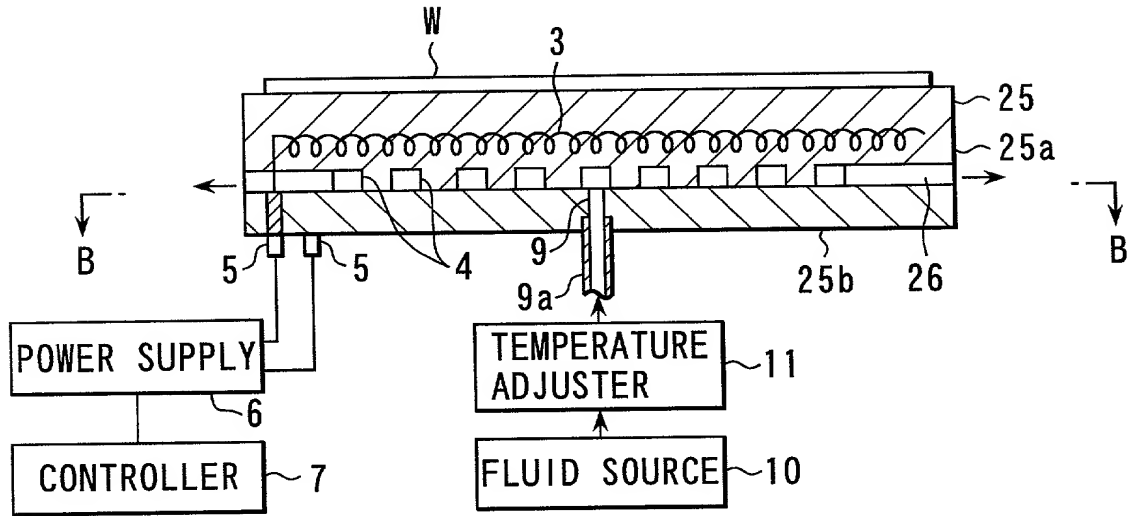


FIG. 8

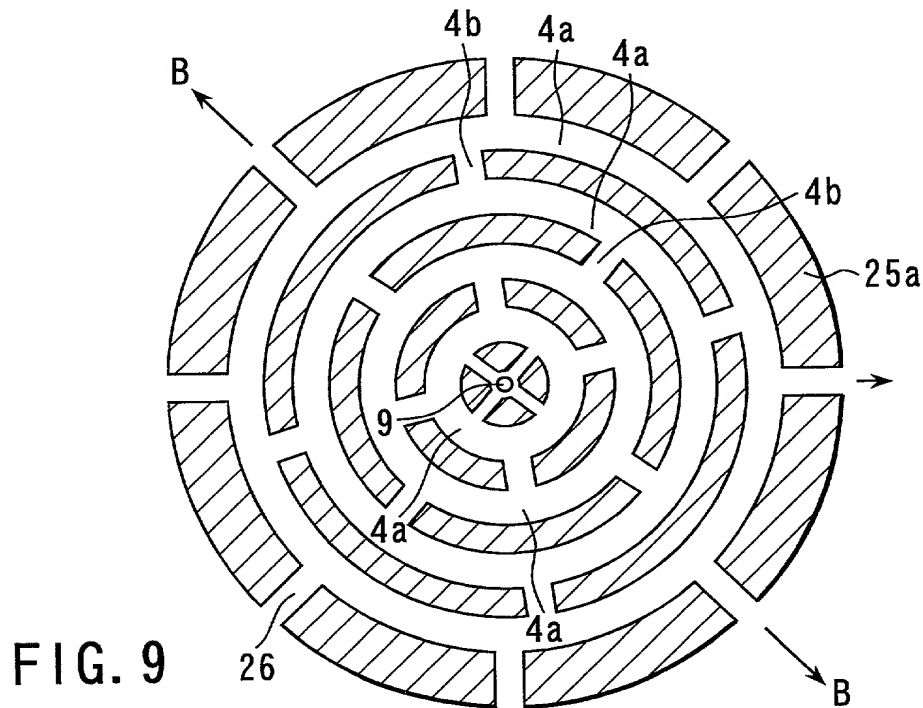


FIG. 9

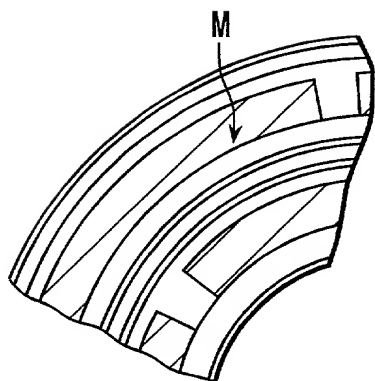


FIG. 10A

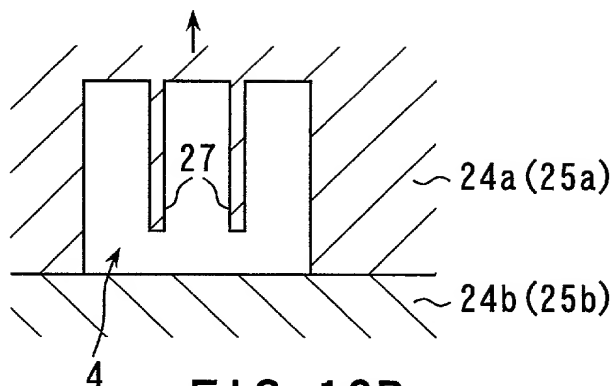


FIG. 10B

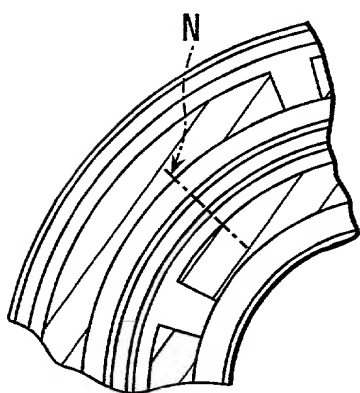


FIG. 11A

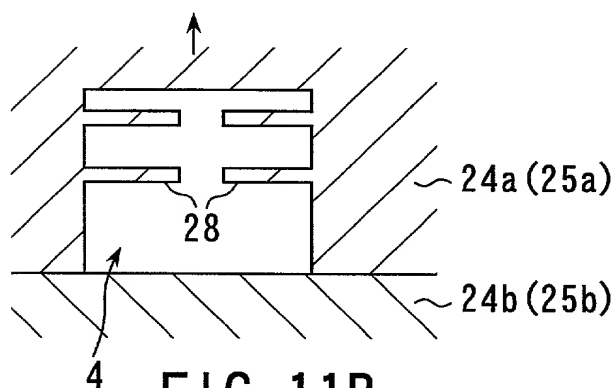


FIG. 11B

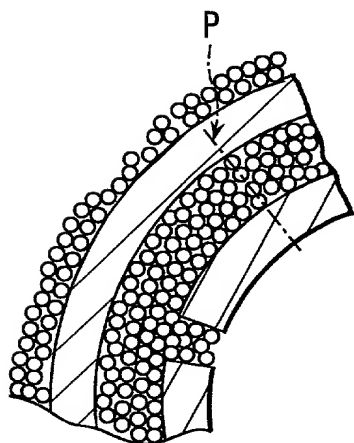


FIG. 12A

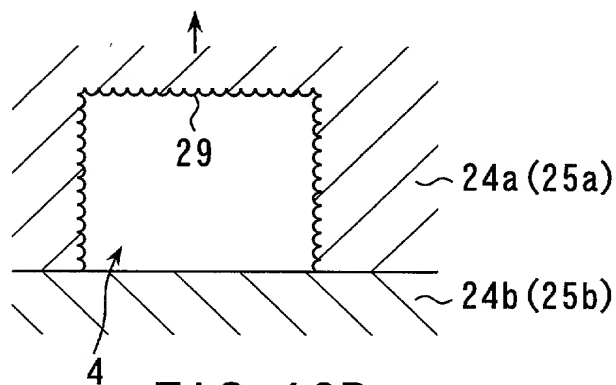
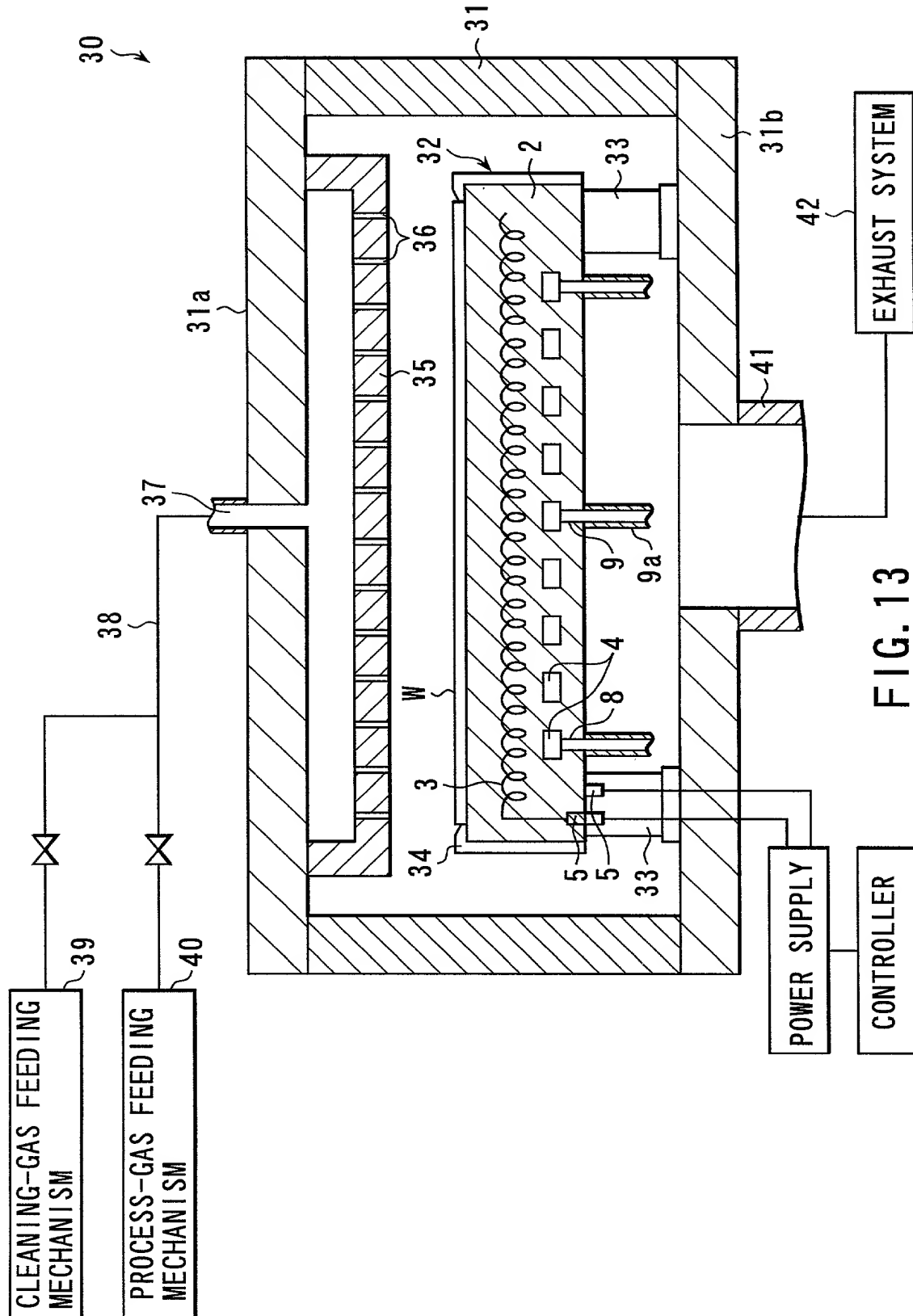
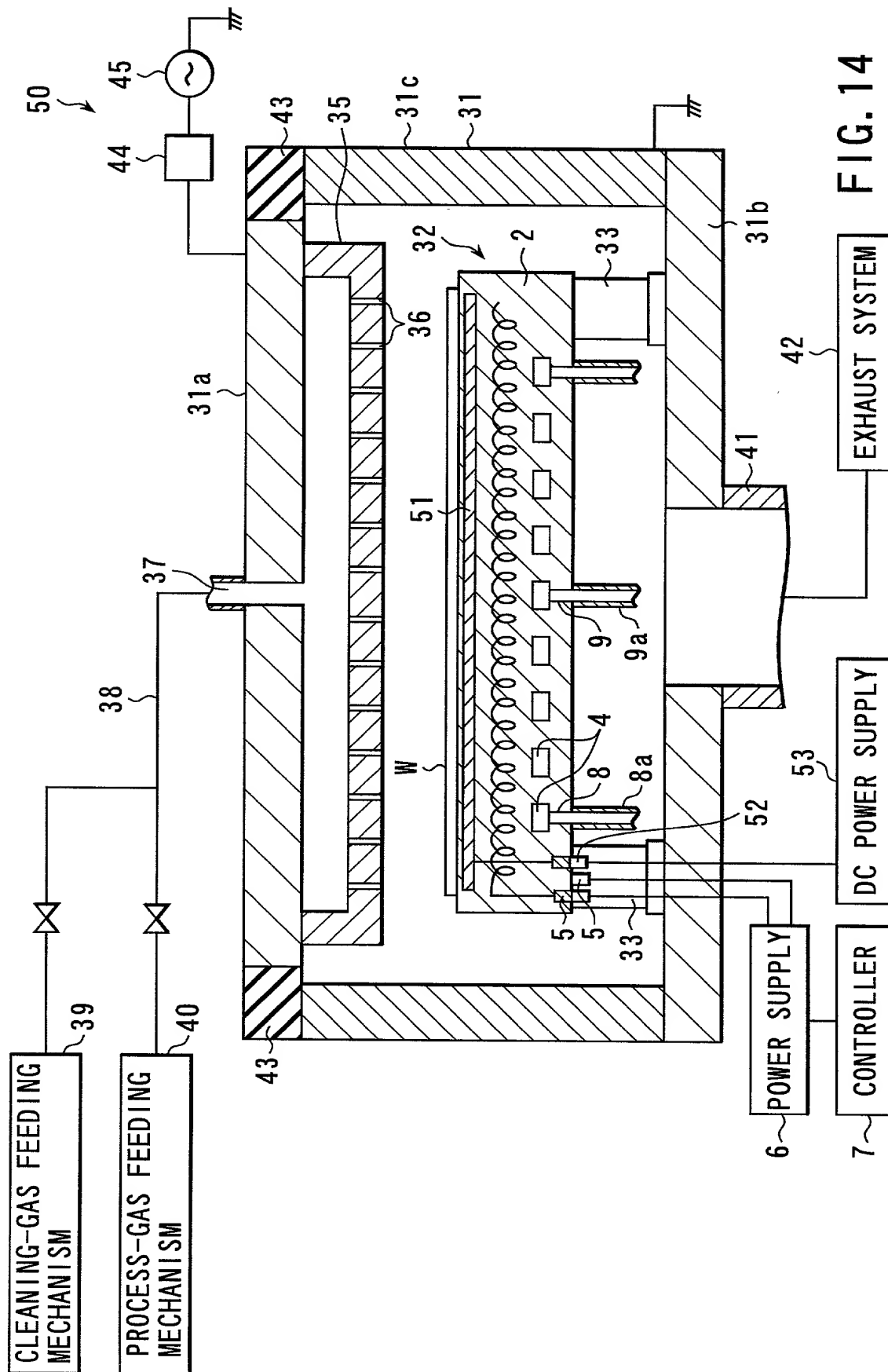
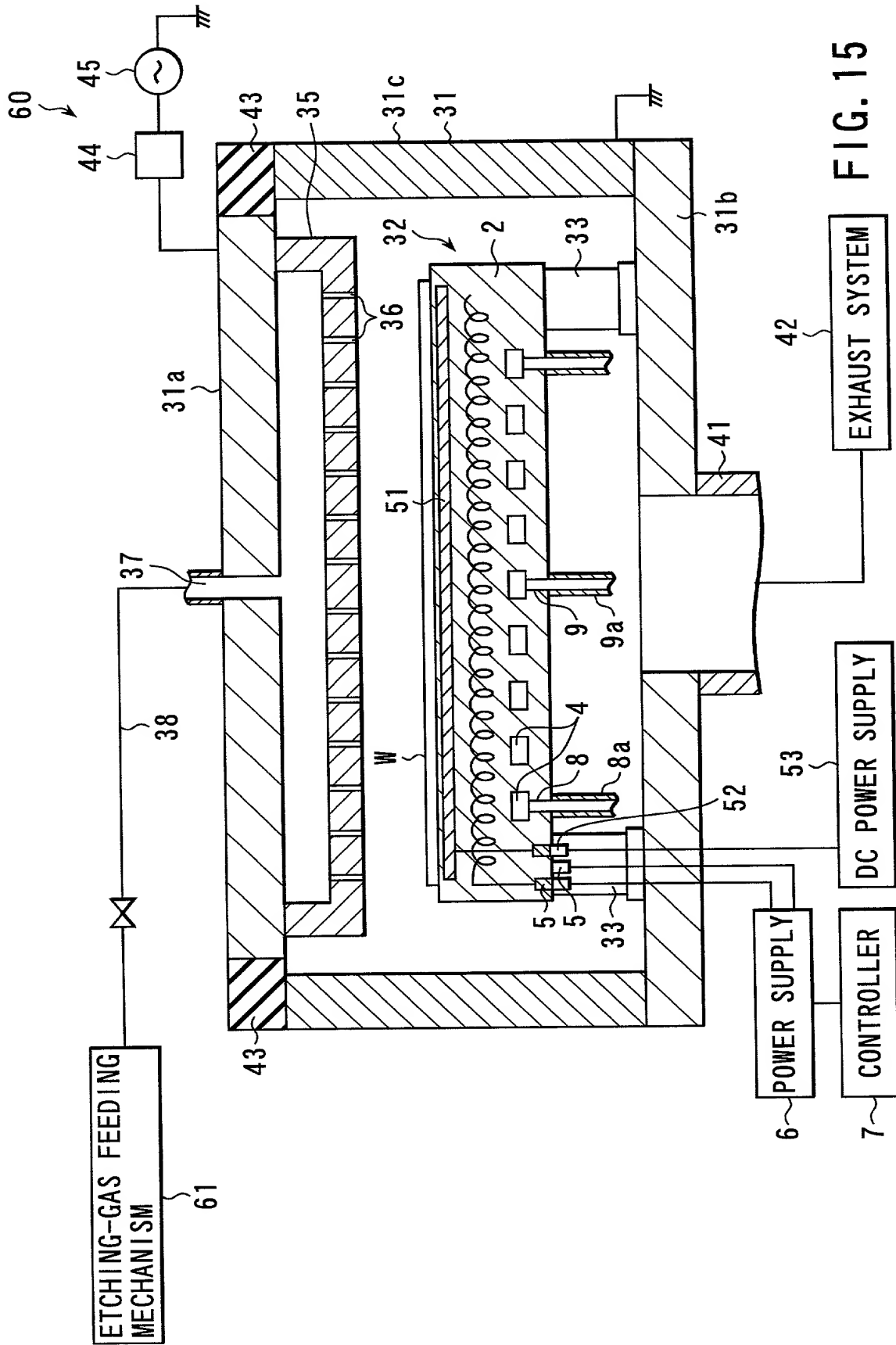


FIG. 12B







Declaration Power of Attorney For Patent Application

特許出願宣言

Japanese Language Declaration

私は、下欄に氏名を記載した発明として、以下の通り宣言する：

As a below named inventor, I hereby declare that:

私の住所、郵便の宛先および国籍は、下欄に氏名に続いて記載したとおりであり、

My residence, post office address and citizenship are as stated below next to my name,

名称の発明に関し、請求の範囲に記載した特許を求める主題の本来の、最初にして唯一の発明者である（一人の氏名のみが下欄に記載されている場合）か、もしくは本来の、最初にして共同の発明者である（複数の氏名が下欄に記載されている場合）と信じ、

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

セラミックスヒータシステム及びそれを搭載する
基板処理装置

CERAMIC HEATER SYSTEM AND
SUBSTRATE PROCESSING APPARATUS
HAVING THE SAME INSTALLED THEREIN

その明細書を
（該当するほうに印を付す）

The specification of which
(check one)

☒ ここに添付する。

☒ is attached hereto.

☐ _____月 _____日に

☐ was filed on _____

as Application Serial No.

出願番号第 _____ 号として

_____ and was amended on

提出し、 _____ 月 _____ 日に補正した。

（該当する場合）

(if applicable)

私は、前記のとおり補正した請求の範囲を含む前記明細書の内容を検討し、理解したことを陳述する。

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第37部第1章第56条(a)項に従い、本願の審査に所要の情報を開示すべき義務を有することを認める。

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, Section 1.56(a).

Japanese Language Declaration

私は、合衆国法典第35部第119条、第172条、又は第365条に基づく下記の外国特許出願又は発明者証出願の外国優先権利益を主張し、さらに優先権の主張に係る基礎出願の出願日前の出願日を有する外国特許出願又は発明者証出願を以下に明記する：

I hereby claim foreign priority benefits under Title 35, United States Code Sec. 119, Sec. 172 or Sec. 365 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior foreign application(s)
先の外国出願

Priority Claimed
優先権の主張

11-341916 (Number) (番号)	JAPAN (Country) (国名)	01/12/1999 (Day/Month/Year Filed) (出願年月日)	<input checked="" type="checkbox"/> Yes あり	<input type="checkbox"/> No なし
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			<input type="checkbox"/>	<input type="checkbox"/>
			<input type="checkbox"/>	<input type="checkbox"/>
			<input type="checkbox"/>	<input type="checkbox"/>

私は、合衆国法典第35部第120条に基づく下記の合衆国特許出願の利益を主張し、本願の請求の範囲各項に記載の主題が合衆国法典第35部第112条第1項に規定の態様で先の合衆国出願に開示されていない限度において、先の出願の出願日と本願の国内出願日又はPCT国際出願日の間に公表された連邦規則法典第37部第1章第56条(a)項に記載の所要の情報を開示すべき義務を有することを認める。

I hereby claim the benefit of Title 35, United States Code, Sec. 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Sec. 112, I acknowledge the duty to disclose any material information as defined in Title 37, Code of Federal Regulations, Sec. 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(Application No.)
(出願番号)

(Filing Date)
(出願日)

(Status: Patented, Pending, Abandoned)
(現況：特許許可済、係属中、放棄済)

(Application No.)
(出願番号)

(Filing Date)
(出願日)

(Status: Patented, Pending, Abandoned)
(現況：特許許可済、係属中、放棄済)

私は、ここに自己の知識に基づいて行った陳述がすべて真実であり、自己の有する情報及び信ずるところに従って行った陳述で真実であると信じ、更に故意に虚偽の陳述等を行った場合、合衆国法典第18部第1001条により、罰金もしくは禁固に処せられるか、又はこれらの刑が併科され、又はかかる故意による虚偽の陳述が本願ないし本願に対して付与される特許の有効性を損なうことがあることを認識して、以上の陳述を行ったことを宣言する。

I hereby declare that all statements made herein of my own knowledge are true; and further that all statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Japanese Language Declaration

(日本語宣言書)

委任状：私は、下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。
(弁理士、または代理人の氏名及び登録番号を明記のこと)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (list name and registration number)

And I hereby appoint Norman F. Oblon (Reg. No. 24,618), Marvin J. Spivak (Reg. No. 24,913), C. Irvin McClelland (Reg. No. 21,124), Gregory J. Maier (Reg. No. 25,599), Arthur I. Neustadt (Reg. No. 24,854), Richard D. Kelly (Reg. No. 27,757), James D. Hamilton (Reg. No. 28,421), Eckhard H. Kuesters (Reg. No. 28,870), Robert T. Pous (Reg. No. 29,099), Charles L. Gholz (Reg. No. 26,395), Vincent J. Sunderdick (Reg. No. 29,004), William E. Beaumont (Reg. No. 30,996), Robert F. Gnuse (Reg. No. 27,295), Jean-paul Lavalleye (Reg. No. 31,451), Stephen G. Baxter (Reg. No. 32,884), Robert W. Hahl (Reg. No. 33,893), Richard L. Treanor (Reg. No. 36,379), Steven P. Weihrauch (Reg. No. 32,829), John T. Goolkasian (Reg. No. 26,142), Richard L. Chinn (Reg. No. 34,305), Steven E. Lipman (Reg. No. 30,011), Carl E. Schlier (Reg. No. 34,426), James J. Kulbaski (Reg. No. 34,648), Richard A. Neifeld (Reg. No. 35,299), J. Derek Msaon (Reg. No. 35,270), Surinder Sachar (Reg. No. 34,423), Christina M. Gadiano (Reg. No. 37,628), Jeffrey B. McIntyre (Reg. No. 36,867), Paul E. Rauch (Reg. No. 38,591), William T. Enos (Reg. No. 33,128) and Michael E. McCabe, Jr., (Reg. No. 37,182) each of whose address is Fourth Floor, 1755 Jefferson Davis Highway, Arlington, Virginia 22202, or any one of them, my attorneys with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent & Trademark Office connected therewith, and request that correspondence be directed to Oblon, Spivak, McClelland, Maier & Neustadt, P.C., Fourth Floor, 1755 Jefferson Davis Highway, Arlington, Virginia 22202.

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Maier & Neustadt, P.C.,

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1755 Jefferson Davis Highway,
Arlington, Virginia 22202

直通電話連絡先：

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(Supply similar information and signature for second and subsequent joint inventors.)